

Comment on "Convective and Radiative Heat Transfer to an Ablating Body"

H. T. YANG*

University of Southern California, Los Angeles, Calif.

THE treatment of the momentum equation in Ref. 1 is identical to that employed in Ref. 2, where additional details are presented. In this regard, boundary conditions are applied at the vehicle wall and immediately behind the shock. The shock-boundary conditions used are the usual Rankine-Hugoniot relations expressed by Eqs. (23) of Ref. 2.

The validity of these boundary conditions appears to be questionable for the following reasons. Physically, the Rankine-Hugoniot relations are valid only if the flowfield downstream as well as upstream of the shock is in translational equilibrium. Since the flowfield behind the shock is assumed viscous in Refs. 1 and 2, it is out of translational equilibrium. The Rankine-Hugoniot relations are therefore not strictly applicable here. Mathematically, Bush,³ as well as Cheng,⁴ has already ruled out the "viscous layer" regime, in which the viscous shock-layer equations are solved subject to the Rankine-Hugoniot relations at the outer edge.

A clarification of this point seems to be desirable.

References

¹ Hoshizaki, H. and Lasher, L. E., "Convective and Radiative Heat Transfer to an Ablating Body," *AIAA Journal*, Vol. 6, No. 8, Aug. 1968, pp. 1441-1449.

² Hoshizaki, H. and Wilson, K. H., "Convective and Radiative Heat Transfer During Superorbital Entry," *AIAA Journal*, Vol. 5, No. 1, Jan. 1967, pp. 25-35.

³ Bush, W. B., "On the Viscous Hypersonic Blunt Body Problem," *Journal of Fluid Mechanics*, Vol. 20, Pt. 3, 1964, pp. 353-367.

⁴ Cheng, H. K., "Hypersonic Shock-Layer Theory of the Stagnation Region at Low Reynolds Number," *Proceedings of the 1961 Heat Transfer and Fluid Mechanics Institute*, Stanford University Press, 1961, pp. 161-175.

Received August 14, 1968.

* Associate Professor. Associate Fellow AIAA.

Reply by Authors to H. T. Yang

H. HOSHIZAKI* AND L. E. LASHER†

Lockheed Missiles & Space Company, Sunnyvale, Calif.

PROFESSOR Yang has brought up an interesting and valid point on the use of inviscid boundary conditions in a viscous shock layer. He points out that "the Rankine-Hugoniot relations are therefore not strictly applicable here." The authors are well aware of this point (see Ref. 1); their reasons for considering the shock layer to be completely viscous in the subject paper were quoted in a previous paper (Yang's Ref. 2):

An important physical mechanism in the shock-layer flow is the coupling between the inviscid and viscous regions created by radiant energy transfer. This coupling is taken into account by considering the entire flow region between the shock and the body simultaneously. The advantage of this approach is that it eliminates the necessity of matching the frequency dependent radiation flux at the inviscid-viscous interface.

Received October 28, 1968.

* Senior Staff Engineer. Member AIAA.

† Research Scientist.

The shock layer is considered to be viscous to avoid the tedious matching of the radiative flux, not because of low Reynolds number effects. In fact the Reynolds numbers are of the order of 10^5 to 10^6 , based on nose radius, freestream velocities, and flow properties behind the shock.

Although the derivation of the thin shock-layer equations is based on the assumption that the shock layer is completely viscous, these equations are also applicable when the outer portions of the shock layer are nearly inviscid. The numerical results presented in the subject paper would not be significantly affected by the use of the proper viscous boundary conditions.

References

¹ Hoshizaki, H., "Shock-Generated Vorticity Effects at Low Reynolds Numbers," LMSC-48381 (ASTIA 210401), Vol. 1, Jan. 1959, Lockheed Missiles & Space Div., Sunnyvale, Calif., pp. 9-43.

² Levinsky, E. S. and Yoshihara, H., "Rarefied Hypersonic Flow Over a Sphere," Paper 1967-61, ARS-AFOSR International Hypersonics Conference, MIT, Aug., 16-18, 1961.

Comment on "Radiation from Conical Surfaces with Nonuniform Radiosity"

D. K. EDWARDS*

TRW Systems Group, Redondo Beach, Calif.

BOBCO¹ presents two graphs giving the shape factor from a receiver to a conical frustum, shown in Fig. 1 and in Figs. 2-9. He indicates that these graphs can be fit with an exponential and that they can then be differentiated and inte-

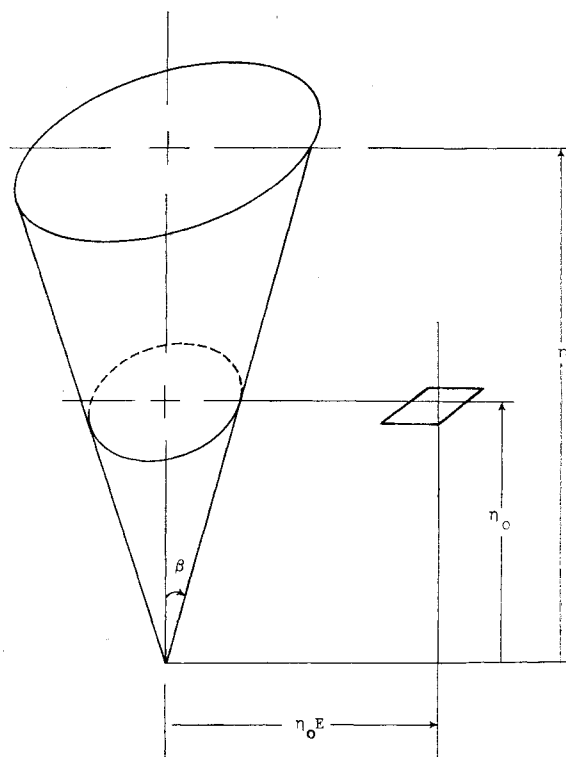


Fig. 1 Cone and receiver.

Received September 20, 1968.

* Consultant; also Professor of Engineering, University of California Los Angeles, Los Angeles, Calif. Member AIAA.